3.20 Gain Functional Element Sensitivity

The function of the antenna is to directionally radiate radar energy pulses and to receive reflected signals including target, noise, and clutter returns. The antenna response is modeled as a gain function of the angle of the target off the antenna boresight, where the gain is usually assumed to be unity.

Several different antenna pattern routines are used for the various radar systems that are modeled, but all conform to the general pattern defined by the function:

$$A_n = \left[\frac{\left(\sin k_n(\theta - \theta_n)\right)}{k_n(\theta - \theta_n)} \right]^2$$

where: A_n is the amplitude or gain

k_n and θ_n are fitted to the particular lobe being modeled.

The antenna gain function implemented in function ANTTRK calculates the fraction of the maximum antenna gain as a function of the angle between the center of the antenna beam and the vector pointing toward the target, clutter patch, or jammer. This function has a maximum of 1.0 when the beam is pointing directly at the point of interest, two lesser maxima or side lobes, and a constant value beyond the second side lobe. A representative response is shown in Figure 3.20-1.

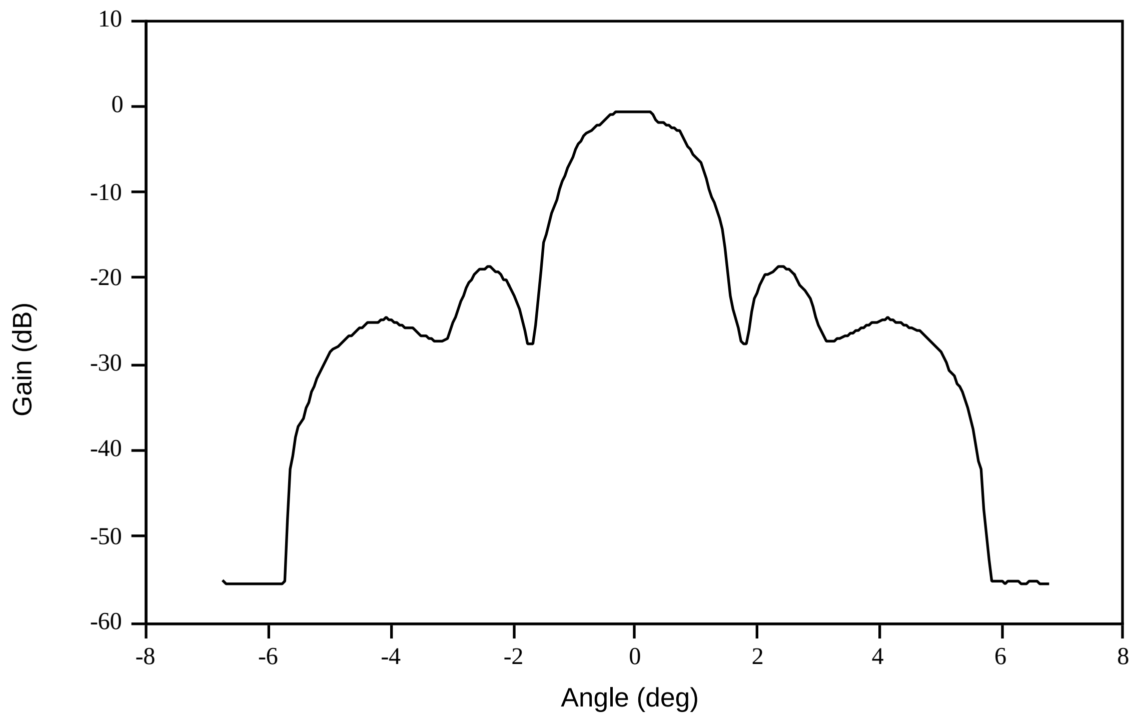

FIGURE 3.20-1. Antenna Gain Pattern as a Function of Angle Off Boresight.

Data Items Required

Data Item		Accuracy	Sample Rate	Comments
5.1.1	Tracking elevation	±0.1 deg	10 Hz	
5.1.2	Tracking azimuth	±0.1 deg	10 Hz	
5.1.3	Antenna elevation	±0.1 deg	10 Hz	
5.1.4	Antenna azimuth	±0.1 deg	10 Hz	
5.1.5	Signal input	±0.5 dB	1 per Az/El	
5.1.6	Signal output	±1% max rec'd pwr	0.1 deg Az by 0.1 deg El/step (from 0 deg to ±2 x beamwith off boresight) 1 deg Az by 1 deg El/step (from 0 deg to ±2 x beamwidth off boresight to 45 deg off boresight) 5 deg Az by 5 deg El/step (from 45 deg off off boresight to 180 deg off boresight)	

3.20.1 Objectives and Procedures

Because antenna response is a function of angle off boresight, azimuth and elevation tracking errors are sensitive to changes in the antenna gain pattern.

To observe the effect of antenna gain pattern on angle tracking errors, *RADGUNS* was executed with the following input conditions:

a.	Model mode:	SNGL/RADR
b.	Target RCS:	1.0 m^2
c.	Target altitude:	200 m
d.	Target flight path:	LINEAR
e.	Radar type:	RAD1
f.	Guns:	Disabled
g.	Output:	Angle errors between boresight and target

3.20.2 Results

Subroutine ANTTRK was modified to implement changes in the main lobe width. The width of the side lobes was not changed; however, a change in the main lobe width results in a change in the position of the side lobes. The antenna response is shown in Figure 3.20-2 for three main lobe widths. Excluding the minima in each function, an increase in main lobe width from nominal results in an increase in antenna gain for a given angle. Conversely, narrowing of the main lobe reduces the gain (or increases attenuation) for the same off-boresight angle.

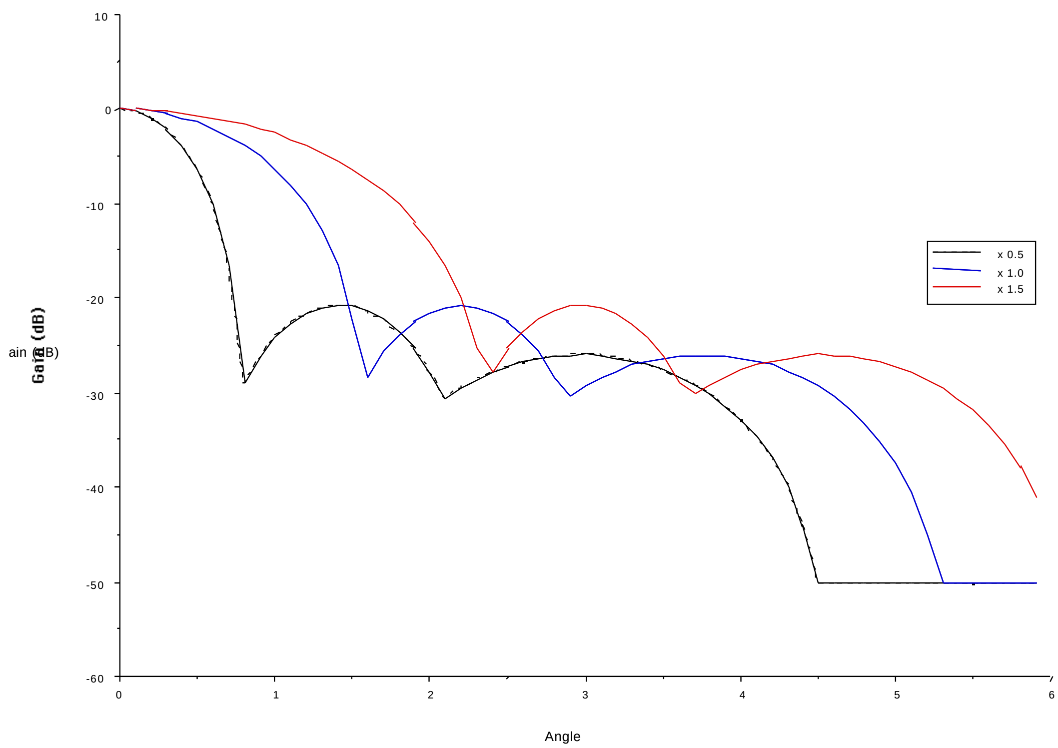

Figure 3.20-2. Effect of Main Lobe Width on Antenna Gain Function.

Figures 3.20-3 through 3.20-6 show the effect of main lobe width on azimuth and elevation tracking errors with and without multipath and clutter. In each case, the threat makes an ingress from 7000 m and crosses over the Y-axis at approximately 75 s.

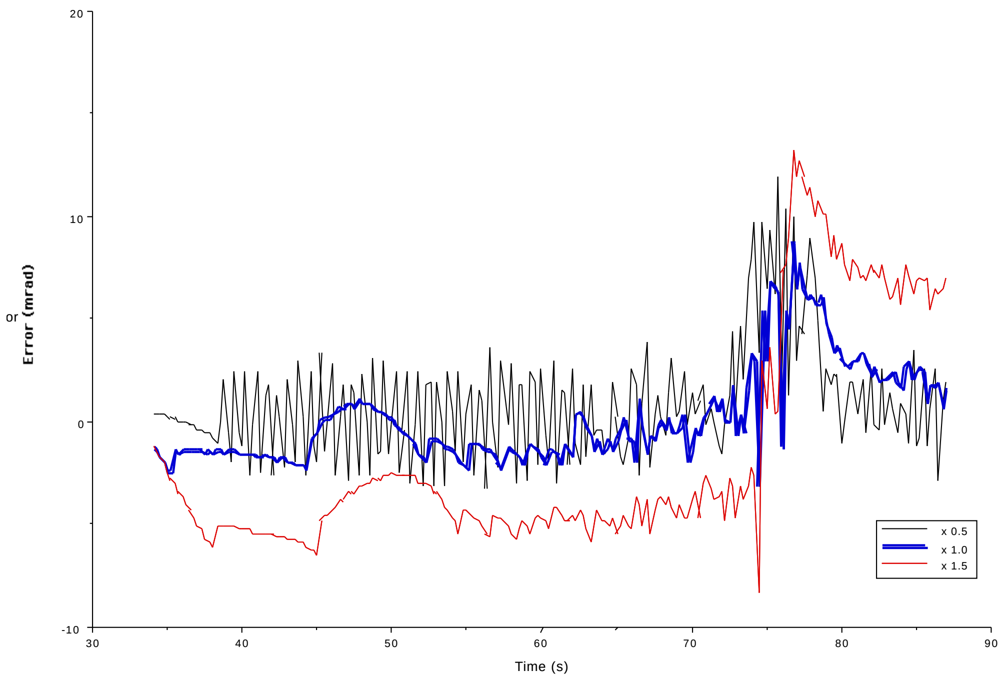

Figure 3.20-3. Effect of Main Lobe Width on Azimuth Tracking Errors (No Multipath or Clutter).

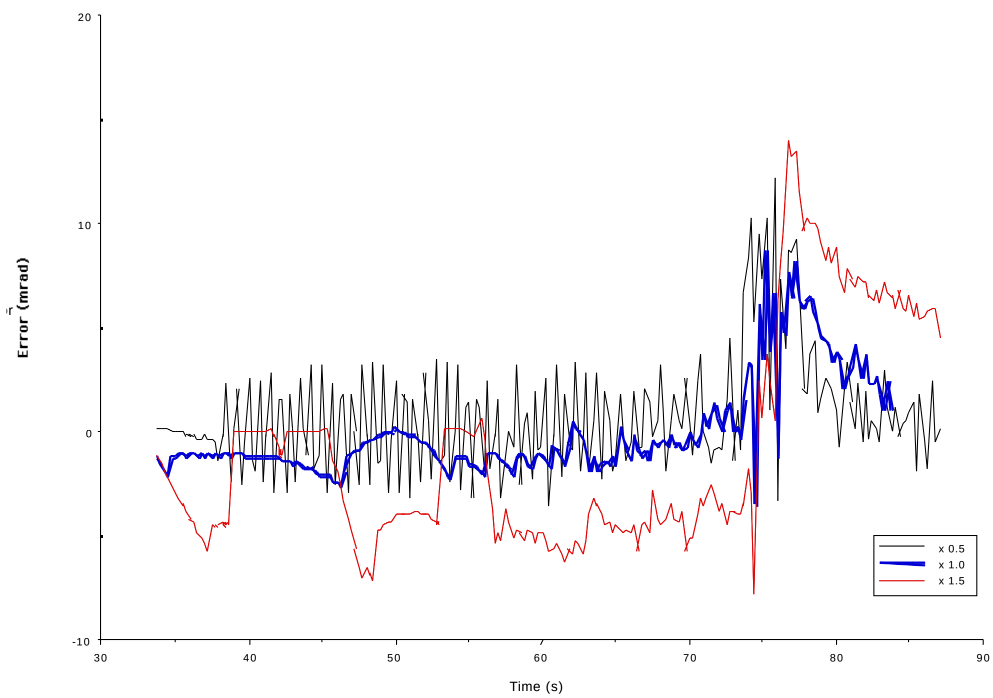

FIGURE 3.20-4. Effect of Main Lobe Width on Azimuth Tracking Errors (Multipath and Clutter);.

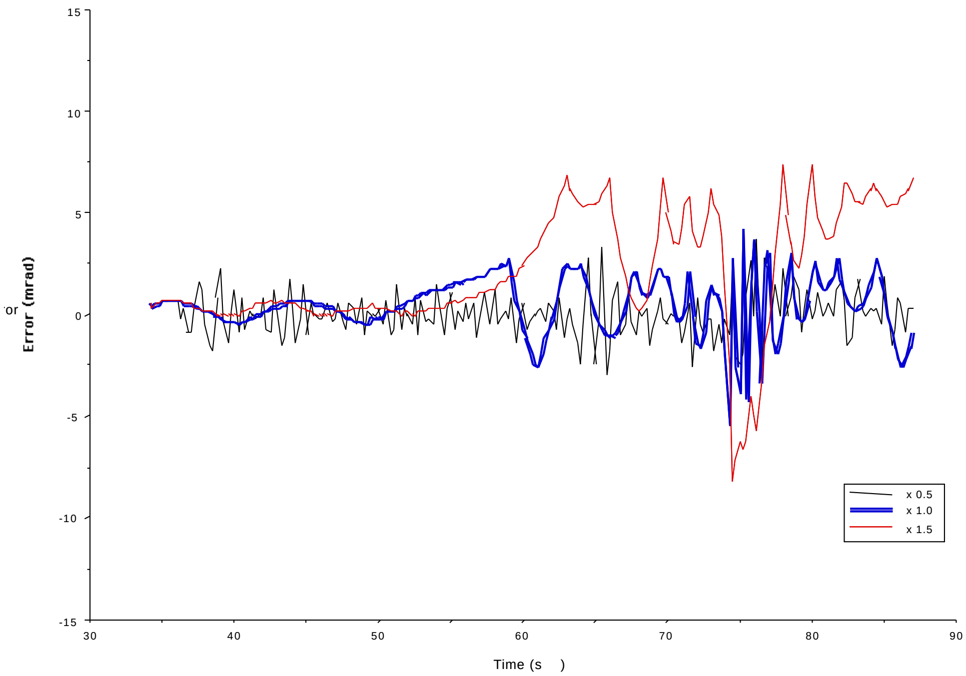

Figure 3.20-5. Effect of Main Lobe Width on Elevation Tracking Errors (No Multipath or Clutter);.

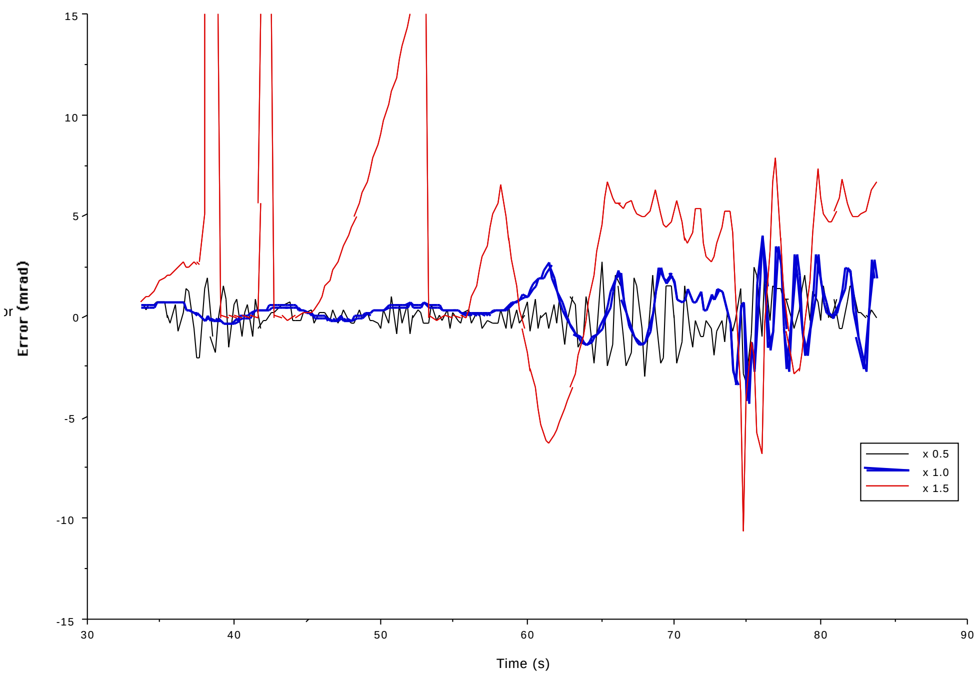

Figure 3.20-6. Effect of Main Lobe Width on Elevation Tracking Errors (Multipath and Clutter).

For both angle trackers, an increase in main lobe width produces an increase in tracking error due to the increase in antenna gain for a given angle off boresight. In addition, the increased width produces a slower response as the antenna gain remains the same for increased angles off boresight. The narrower main lobe, while generating similar (to nominal) mean values in both azimuth and elevation errors, displays a fluctuating pattern of high sensitivity.

The addition of multipath and clutter returns causes a significant increase in elevation tracking errors at the increased main lobe width. This is due to the wider beamwidth which allows more multipath and clutter return. The return is proportional to the range from the threat with multipath return being more significant at greater ranges. This return is significant enough to cause the angle tracker to break lock. Multipath and clutter contribute little to azimuth tracking errors.

3.20.3 Conclusions

For the nominal antenna gain pattern with no multipath or clutter, azimuth errors on the order of -3 to 9 mrad and elevation errors on the order of -5 to 4 mrad can be expected. A 50% increase or decrease in the main lobe width of the antenna gain pattern will produce a variation in azimuth errors between -8 and 13 mrad and in elevation errors between -8 and 7 mrad. Thus a 50% change in the main lobe width causes a ± 5 mrad variance in azimuth error and a ± 3 mrad variation in elevation error.